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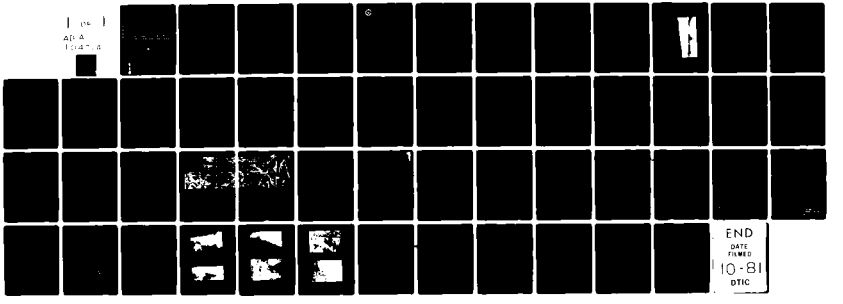

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SAYERSBROOK LAKE DAM
WASHINGTON COUNTY, MISSOURI
MO 30112

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

DECEMBER 1978

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REPORT DOCUMENTATION PAGE

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7. AUTHOR(s) Horner & Shifrin, Inc.	8. CONTRACT OR GRANT NUMBER(s) DACW43-78-C-0143
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

REPLY REFER TO

SUBJECT: Sayersbrook Lake Dam Phase I Inspection Report

This report presents the results of a field inspection and an evaluation of the Sayersbrook Lake Dam.

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood.
2) Overtopping could result in dam failure.
3) Dam failure significantly increases the hazard to loss of life downstream.

SIGNED

12 JAN 1979

SUBMITTED BY: _____ _____
Chief, Engineering Division — Date

SIGNED

13 JAN 1979

APPROVED BY: _____ _____
Colonel, CE, District Engineer — Date

SAYERSBROOK LAKE DAM
WASHINGTON COUNTY, MISSOURI

MISSOURI INVENTORY NO. 30112

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

DECEMBER 1978

HS-7848-10

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Sayersbrook Lake Dam
State Located:	Missouri
County Located:	Washington
Stream:	Ashley Branch Fourche a Renault
Date of Inspection:	22 August 1978

The Sayersbrook Lake Dam was visually inspected by engineering personnel of the office of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of the inspection was to assess the general condition of the dam with respect to safety and, based upon this inspection and available data, determine if the dam poses a hazard to human life or property.

The following summarizes the findings of the inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team.

Based on a visual inspection, the present general physical condition of the dam is considered to be satisfactory; however, the following deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam:

1. A few small trees and patches of brush that may conceal animal burrows exist on the downstream slope of the dam. Tree roots and animal burrows can provide passageways for seepage that may develop into a piping condition.

2. Erosion of the downstream slope, believed to be due to drainage of storm runoff, has occurred at the intersection of the embankment and the left abutment. Erosion of the embankment will reduce the section and may impair the stability of the dam.

3. The emergency spillway is located within the embankment and has only a grass cover to protect it from erosion by lake outflow. A grass covered slope in a fill section is not considered adequate to prevent erosion by spillway flow. Erosion of this section could result in failure of the dam.

4. Lake water was noticed emerging in the bottom of the spillway channel at a point approximately 10 feet downstream of the concrete weir. It appears that a seepage path may have developed beneath the spillway wall. Seepage at this location could develop into a piping condition that could affect the operation of the lake.

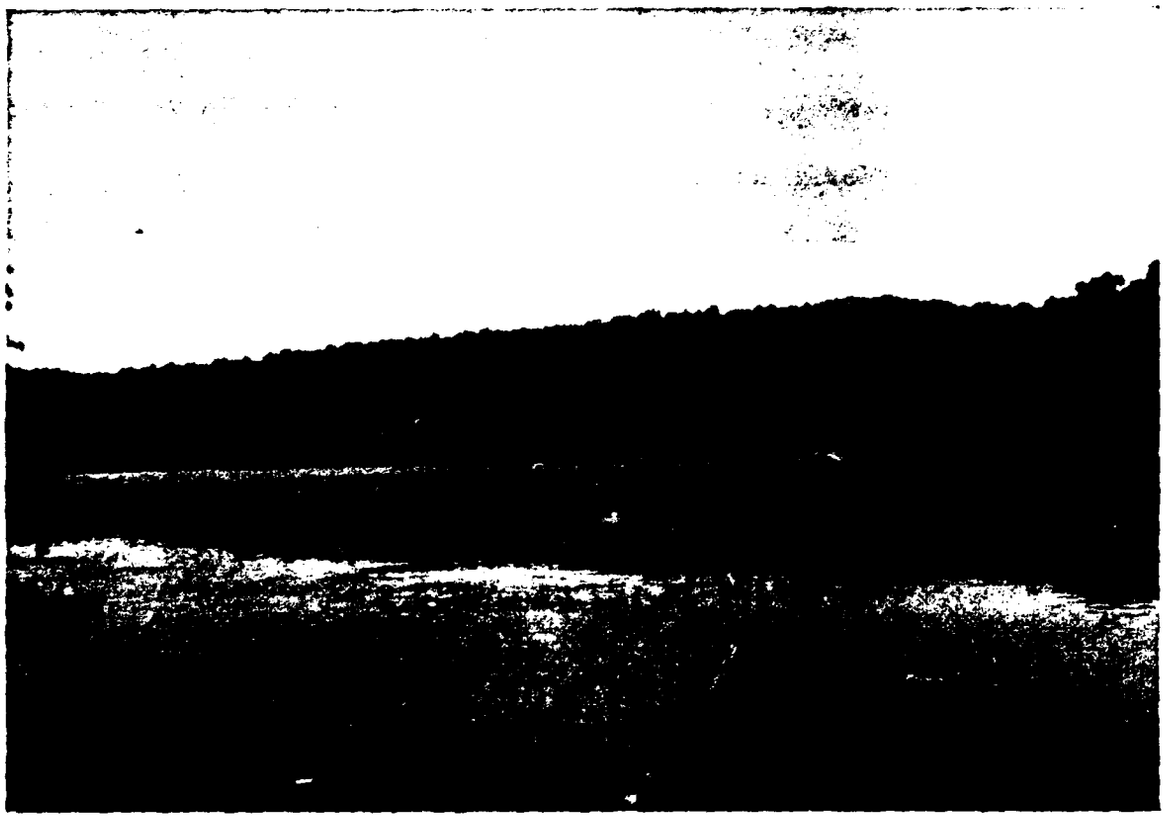
5. A heavy growth of small willow trees and brush exists in the spillway exit channel. This growth will restrict spillway flow and could result in overflow of the channel that may produce erosion of the adjacent embankment. Erosion of the embankment may impair the stability of the dam.

According to the criteria set forth in the recommended guidelines (see text) the spillway design flood for this dam, which is classified as intermediate in size and of high hazard potential, is specified to be the Probable Maximum Flood (PMF). PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. Results of a hydrologic/hydraulic analysis indicated that the existing spillways (concrete weir plus emergency) are inadequate to pass the lake outflow resulting from a storm of PMF magnitude without overtopping the dam. The spillways are capable, however, of passing lake outflow resulting from the 1 percent chance (100-year frequency) flood and lake outflow corresponding to about 49 percent of the PMF. The length of the downstream damage zone, should failure of the dam occur, is estimated to be ten miles. Within the first mile of the possible damage zone are two homes, a swimming pool and recreation area, and two county roads.

A review of available data did not disclose that seepage and stability analyses of the dam were performed. This is considered a deficiency and should be rectified.

It is recommended that the Owner take the necessary action in the near future to correct or control the safety defects and deficiencies reported herein.

Albert B. Becker, Jr.
P.E. Missouri E-9168



OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
SAYERSBROOK LAKE DAM - ID NO. 30112

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
SAYERSBROOK LAKE DAM - ID NO. 30112

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. National Dam Inspection Act, Public Law 92-367, dated 8 August 1972.

b. Purpose of Inspection. The purpose of this visual inspection was to made an assessment of the general condition of the dam with respect to safety and, based upon available data and this inspection, determine if the dam poses a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams," Appendix D to "Report of the Chief of Engineers on the National Program of Dams," dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The Sayersbrook Lake Dam is an earthfill type embankment rising approximately 65 feet above the original stream bed. In general, the embankment has an upstream slope of 1v on 1.3h above the waterline, a crest width of about 22 feet, and a downstream slope of 1v on 2.2h. The upstream face of the dam is protected by riprap. Lake level is governed by overflow of a concrete weir at the principal spillway which is located in the hillside at the right abutment. Removable wood planks are used to raise the level of the impounded water approximately 11 inches for irrigation purposes. A bridge, approximately 12 feet wide, crosses the spillway along the longitudinal axis of the dam. An emergency spillway, approximately 4.5 feet higher than the principal spillway weir and 4.5 feet lower than the

top of the dam, is located immediately to the left of the principal spillway within the embankment. A 24-inch diameter pipe serves the lake for drawdown purposes and a 2-inch diameter pipe allows water from near the bottom of the lake to flow continuously downstream.

b. Location. The dam and lake are located on the Ashly Branch of the Fourche a Renault, approximately five miles north of Shirley, Missouri, in Washington County, as shown on the Regional Vicinity Map, Plate 1. The dam is located in Section 28, Township 38 North, Range 1 East, approximately five miles north of the intersection of State Routes 8 and AA.

c. Size Classification. The classification for size based on the height of the dam and storage capacity is categorized as intermediate. (Per Table 1, Recommended Guidelines for Safety Inspection of Dams.)

d. Hazard Classification. According to the St. Louis District, Corps of Engineers, the Sayersbrook Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, serious damage to homes, extensive agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. The estimated flood damage zone, should failure of the dam occur, as determined by the St. Louis District, extends ten miles downstream of the dam. Within the first mile of the possible damage zone are two homes, a swimming pool and recreation area, and two county roads.

e. Ownership. The lake and dam are owned by Mr. Herbert W. Sayers, Rural Route 2, Potosi, Missouri, 63664.

f. Purpose of Dam. The dam impounds water for the purposes of irrigation and recreation.

g. Design and Construction History. The dam was constructed during 1956 and 1957 by R. G. Aldridge & Sons, Contractors, of Kansas City, Missouri. According to the Owner, no formal engineering data was employed or analyses

made to determine the stability of the dam or the hydrologic/hydraulic requirements of the spillway. According to the Owner, a group of undergraduate students from the University of Missouri at Rolla made a hydrologic study of the lake watershed and spillway sometime about 1969. Based on this study, the students recommended raising the dam five feet as well as the provision of an emergency spillway. The Owner retained the firm of Russell & Axon, Consulting Engineers, St. Louis, Missouri, who agreed that the dam should be raised and a second spillway provided and subsequently prepared plans for these improvements. In 1971, the Loomis Construction Company, Potosi, Missouri, raised the dam the specified five feet and constructed the new spillway. However, neither the riprap specified by Russell & Axon to be placed on the slopes nor the concrete slab to be installed at the spillway crest were constructed. No data relating to the design of the dam or the spillways are available.

h. Normal Operational Procedures. The lake level is unregulated. Wood planks can be installed at the concrete weir to raise the level of the lake approximately 11 inches when so desired.

1.3 PERTINENT DATA

a. Drainage Area. The lake watershed is virtually undeveloped and, in a natural state, covered with timber. The watershed area above the dam amounts to approximately 820 acres. The watershed is outlined on Plate 1.

b. Discharge at Damsite.

(1) Estimated maximum flood at damsite ... 500 cfs[1]

(2) Spillway capacity (principal only) ... 620 cfs (W.S. elev. 899.6)

(3) Spillway capacity (principal plus emergency) ... 3,920 cfs (W.S. elev. 903.8)

(1) Based on an estimated high water elevation of 899.0 as indicated by the Owner.

c. Elevation (ft. above MSL). The top of the concrete spillway weir was assumed to be elevation 895, the basis for this assumption being the elevation for the lake water surface shown on the 1958 Shirley, Missouri, Quadrangle Map 7.5 minutes series, and assumed to be the normal pool level.

(1) Top of dam ... 903.8 (min.)

(2) Normal pool (spillway crest) ... 895.0

(3) Irrigation pool ... 895.9 (11-inch planks in place)

(4) Streambed at centerline of dam ... 839± (est.)

(5) Maximum known tailwater ... Unknown

(6) Pool at date of inspection ... 895.0

d. Reservoir.

(1) Length of maximum pool (elev. 903.8) ... 3,700 ft.

(2) Length of normal pool (elev. 895.0) ... 3,100 ft.

e. Storage.

(1) Normal pool ... 656 ac.ft.

(2) Irrigation pool (incremental) ... 52 ac.ft.

(3) Top of dam (incremental above irrigation pool) ... 382 ac.ft.

f. Reservoir Surface.

(1) Top of dam ... 55 acres

(2) Irrigation pool ... 38 acres

(3) Normal pool ... 36 acres

g. Dam. Data tabulated below per survey made on date of inspection unless otherwise indicated.

(1) Type ... Earthfill, homogeneous

(2) Length ... 920 ft.

(3) Height ... 63 ft.

(4) Top width ... 22 ft.

(5) Side slopes

(a) Upstream ... 1v on 1.3h (riprap, above waterline)

(b) Downstream ... 1v on 2.2h

(6) Cutoff ... Core trench (per Owner)

(7) Slope protection

(a) Upstream ... Stone riprap

(b) Downstream ... Grass

h. Principal Spillway.

(1) Type ... Concrete, uncontrolled[1]

(2) Length of weir ... 33 ft.

(3) Crest elevation ... 895.0

(4) Upstream channel ... Lake

(5) Downstream channel ... Earth cut section

i. Emergency Spillway.

(1) Type ... Uncontrolled, broad-crested section

(2) Length (bottom) ... 60 feet

(3) Elevation ... 899.6 (ft. above MSL)

(4) Entrance channel ... Lake

(5) Exit channel ... Embankment

(6) Slope protection ... Grass

j. Outlet for Lake Drawdown.

(1) Type ... 24-inch steel pipe

(2) Invert elevation

(a) Upstream ... Unknown

(b) Downstream ... 840.9

(3) Control ... Valve at inlet end of pipe; valve operating rod extends to dam crest.

(1) Can be raised approximately 11 inches by installing wood planks.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

No engineering data relating to the original design of the dam are known to exist. Plans prepared by Russell & Axon, Consulting Engineers (reference Plates 2 and 3) for raising the dam approximately five feet and for provision of a new spillway, indicate how these improvements were to be constructed. However, according to a representative of Russell & Axon, design data relating to these improvements could not be located. The 1969 study of the lake watershed by the students from the University of Missouri at Rolla (UMR), wherein the original recommendations for raising the dam and provision of an emergency spillway were made, was also unavailable.

In 1969, in order to fulfill a requirement for a master's degree in civil engineering, a graduate student from UMR prepared a thesis entitled "Clay Mineralogy and Compaction Characteristics of Residual Clay Soils in Earth Dam Construction in the Ozark Province of Missouri." As the title indicates, the thesis is primarily a study of the nature of clayey residual soils and the factors which affect the compaction of these soils. Some of the soil data used in this study was obtained from the Sayersbrook Lake Dam. Page 170 of this treatise (Reference Chart 2-1), is considered germane to this investigation and is included herein. The dam sections and comments pertain to the condition of the structure prior to raising the dam in 1971.

2.2 CONSTRUCTION

The only known record of the construction of the dam consists of a 15 minute long, 8 mm color film, taken by the Owner, showing the dam at various stages of completion. This film was viewed by the inspection team and it did show that a core trench was constructed. The total depth of the trench could not be determined from the film. Compaction of the fill in the embankment was evidently accomplished using a sheepsfoot roller.

According to the Owner's records, a slide occurred at the downstream slope near the center of the dam while placing the fill for raising the dam in 1970. The slide was repaired and the Owner reports no further problems at this location.

According to the Owner's records and drawings prepared by Russell & Axon, the invert of the emergency spillway was indicated to be 2 feet higher than the top of the concrete weir at the emergency spillway and 7 feet lower than the top of the dam. Based on elevations obtained by survey at the time of the inspection, the difference between the emergency spillway invert and the top of the weir was found to be approximately 4.5 feet. The top of the dam was found to be about 9 feet higher than the concrete weir at the principal spillway.

2.3 OPERATION

The lake level is governed by overflow of a concrete weir type spillway. Wood planks can be installed above the weir to raise the lake level approximately 11 inches. The Owner reports that this is done during periods when irrigation requirements place a high demand on the supply of water available from the lake. An emergency spillway, approximately 5 feet higher than the concrete weir, is also available if lake outflow conditions warrant. According to the Owner, the maximum loading on the dam was a storm that produced a rise of about 5 feet above normal pool level, or near the invert level of the emergency spillway.

2.4 EVALUATION

a. Availability. Engineering data for assessing the design of the earthfill dam and spillway were unavailable.

b. Adequacy. No data available. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the dam and spillways was made by Horner & Shifrin engineering personnel on 22 August 1978. Also inspected at this time was the area downstream of the dam, including the various road crossings between the dam and State Highway 185 (formerly 114) for a distance of about five miles. Photographs of the dam taken at the time of the inspection are included on Pages A-1 thru A-3 of the Appendix.

b. Dam. The visible portions of the upstream and downstream faces of the dam (see Photos 1, 2, and 3) appeared to be in sound condition although several small and medium-size trees and patches of brush exist on the downstream face. Riprap, consisting of limestone rock that varies in size from about 2-inches to about 12-inches, serves to protect the upstream slope from erosion. The riprap extends to a level approximately 3 feet above the normal waterline. The downstream slope at the junction with the left abutment is eroded, apparently by storm drainage runoff, to a maximum depth of about 3 feet. No lake seepage was noticed at the downstream toe of slope or at the junction of the embankment and abutments.

The extension rod for operation of the valve on the 24-inch lake drawdown pipe appeared to be in sound condition although the surface was rusted where exposed and encrusted below the waterline. The Owner reported that the valve has not been operated in several years. According to the Owner, the drawdown pipe is a 24-inch corrugated metal pipe section, encased in concrete for its entire length. Examination of the outlet end of the pipe indicated that the minimum concrete encasement was about 6-inches and was square in cross section. A 2-inch steel pipe is hung from the intrados of the 24-inch pipe. The 2-inch pipe extends approximately 6-inches beyond the end of a 55 gallon steel drum (see Photo 4) that serves to protect the pipe. A globe-type valve located at the end of the 2-inch pipe serves to control the flow. At the time of the

inspection the valve was open and discharging lake water. The valve was found to be in good condition and operable. The Owner could not recall the details of how the 2-inch pipe projected through the 24-inch pipe and reached the lake. The Owner did indicate that the 2-inch pipe projects through the 24-inch pipe at a point just downstream of the 24-inch valve.

Based on the appearance and composition of the soil used to build the dam as viewed in the color film of construction provided by the Owner, examination of the residual soil in the borrow area where materials were obtained to raise the dam, and the soil at the surface in eroded areas of the dam, it appears that the soil used to construct the dam was a stoney, red clay. The soil classification values (LL = 105, PL = 41, PI = 64) reported on Chart 2-1 indicate the material used to be an inorganic clay of high plasticity confirming the observations reported above.

c. Principal Spillway. The concrete weir at the principal spillway, including the 12-inch high piers for support of the wood planks and the concrete bridge crossing the spillway approach channel (see Photo 5), appeared to be in sound condition. The clear distance between the concrete weir and the underside of the bridge was measured to be approximately 3.5 feet. Water, believed to be from the lake, was emerging in the bottom of the spillway channel at a point approximately 10 feet downstream of the concrete weir. A heavy growth of small willows and brush was noticed in the exit channel (see Photo 6) between the spillway crest and the downstream channel.

d. Emergency Spillway. The emergency spillway is located in the embankment and, with the exception of riprap at the upstream face of the dam, is grass covered. The exit channel for the emergency spillway joins the downstream channel at a point approximately 60 feet below the dam and at an angle that appeared to be slightly less than 90 degrees to the alignment of the channel.

e. Reservoir. The bank contiguous to the lake appeared to be in satisfactory condition and was covered with grass and trees. No appreciable sedimentation in the lake was noticed or reported by the Owner.

f. Downstream Channel. The downstream channel is unimproved. Ashly Branch joins the Fourche a Renault about 1 mile below the dam and Fourche a Renault joins Mineral Fork approximately 8 miles below the dam. State Highway 185 crosses Fourche a Renault approximately 5 miles below the dam.

3.2 EVALUATION

The deficiencies observed during this inspection are not considered significant to warrant immediate remedial action.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 FINDINGS

The spillway is uncontrolled. Wood planks can be installed to raise the level of the lake approximately 11 inches above normal pool. The water surface level is governed by rainfall runoff, evaporation, seepage, and the capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM AND SPILLWAY

According to the Owner, the grass on the dam crest is mowed occasionally during the growing season. It was also reported that trees appearing in the upstream and downstream faces of the dam are cut to ground level once a year; however, the grass on the slopes is not cut at all. No maintenance of the spillways or outlet channel has been performed since completion of construction of these appurtenances.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

No spillway control facilities exist at this time. The valve on the 24-inch lake drawdown pipe was closed and not leaking at the time of the inspection. According to the Owner, it has not been operated in several years for fear of not being able to re-close it. The valve on the 2-inch pipe, used to provide continuous flow downstream, is maintained in working condition.

4.4 DESCRIPTION OF ANY WARNING SYSTEMS IN EFFECT

The inspection did not reveal the existence of a dam warning system.

4.5 EVALUATION

Lack of maintenance is considered detrimental to the safety of the dam. It is recommended that maintenance of the downstream slope of the dam include cutting the brush, and that maintenance of the spillway outlet channel be included along with maintenance of the valve on the lake drawdown pipe.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data are not available.

b. Experience Data. The drainage area and lake surface area were developed from the USGS Shirley, Missouri, and Richwoods, Missouri, Quadrangle Maps. The proportions and dimensions of the spillways and dam were determined from surveys made during the inspection.

c. Visual Observations.

(1) A concrete bridge structure spans the principal spillway approach channel limiting the waterway area available for lake outflow at this location. The opening is of such a size that plugging by debris is possible during large overflows.

(2) Wood planks, approximately 11 inches high, can be placed above the concrete weir in order to raise the lake water surface above the normal pool level. These planks, if in place, further reduce the waterway area available for lake outflow at this spillway location.

(3) The principal spillway and outlet channel are located at the right abutment of the dam. Spillway releases within the limited capacity of the principal spillway section will not endanger the integrity of the dam. Lake level above the underside of the bridge across the approach channel or pressure exerted on the structure due to plugging of the opening below the structure could endanger the structure. Also, plugging of the opening at the principal spillway will require additional capacity at the emergency spillway that may not be available.

(4) The crest and exit channel of the emergency spillway have a grass cover to protect these sections from erosion by lake outflow. Spillway

releases could endanger the integrity of the dam since the emergency spillway is located within the embankment, which may erode when spill occurs.

d. Overtopping Potential. The results of a dam overtopping analysis are as follows. (Computations are based upon the assumption that the wood planks are in place during the flooding events.)

Ratio of PMF	Q - Peak Outflow (cfs)	Max. Lake Water Surface Elev.	Max. Depth of Flow Over Dam (Elev. 903.8)	Duration of Overtopping of Dam (Hours)
0.49	3,920	903.8	0	0
0.50	4,040	903.9	0.1	0.2
1.00	12,990	905.8	2.0	1.1
100-Year Flood	970	900.8	0	0

The computations clearly indicate that the spillway sections are not adequate for the PMF and are adequate or nearly so for the 1/2 PMF. However, it should be recognized that during the occurrence of the 1/2 PMF, depth of flow over the emergency spillway during the peak will be about 4 feet. Calculations indicate that the duration of the flow over the spillway could be about 8 hours, and at depths of one foot or greater, about 5 hours. Since the emergency spillway has been built in the embankment of the dam without any protection against erosion other than grass cover, serious doubts exist as to the physical adequacy of the spillway to maintain the existing section throughout the overflow period.

The flow safely passing the spillways (principal plus emergency) just prior to overtopping amounts to about 3,920 cfs, which is equivalent to the outflow from about 49 percent of the probable maximum flood, and exceeds the outflow from the 1 percent chance (100-year frequency) flood. The flow passing the principal spillway with the lake level just below the underside of the bridge structure (elevation 898.5) amounts to about 380 cfs, and with the lake level at the invert of the emergency spillway (elevation 899.6) the flow amounts to about 620 cfs.

Procedures and data for determining the probable maximum flood, the 100-year frequency flood, and the discharge rating curve for flow over the spillways and the dam crest are presented on Pages B-1 and B-2 of the Appendix. A listing of the HEC-1 (Dam Safety Version) input data is shown on Pages B-3 through B-5 of the Appendix. A copy of the computer output table entitled "Summary of Dam Safety Analysis" is presented on Page B-6 of the Appendix.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations that adversely affect the structural stability of the dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design and construction data relating to the structural stability of the dam, except as noted herein, are known to exist. Based upon the film of the construction taken by the Owner, it is assumed that the dam was constructed with a core trench and that the fill in the embankment was compacted using a sheepsfoot roller.

c. Operating Records. With the exception of the valves on the 24-inch and 2-inch lake drain pipes, no facilities requiring operation exist at this dam. It is not known if the 24-inch valve can be operated at this time. Wood planks can be installed at the spillway to raise the level of the lake approximately 11 inches above the normal pool level. According to the Owner, no records have been kept of lake level, spillway discharge, dam settlement, or seepage.

d. Post Construction Changes. Post construction changes that affect the structural stability of the dam are discussed in Section 2, paragraphs 2.1 and 2.2. Computations for the analyses of the structural stability of the dam for the additional height of fill over the original dam embankment are not known to exist.

e. Seismic Stability. Since the dam is located within a Zone II seismic probability area, an earthquake of the magnitude predicted is not expected to produce a hazardous condition to the dam, provided that static stability conditions are satisfactory and conventional safety margins exist.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. A hydraulic analysis indicated that the principal spillway is capable of passing lake outflow of about 620 cfs before the level of the lake exceeds the invert of the emergency spillway. A similar analysis indicated that the combined capacity of the principal and emergency spillways is about 3,920 cfs without the level of the lake exceeding the low point in the top of the dam. These discharge capacities assume that the 11-inch high wood planks are in place at the spillway weir and that there is no restriction to flow other than the bridge structure at the spillway. A hydrologic analysis of the lake watershed area, as discussed in Section 5, indicated that for a storm runoff of probable maximum flood magnitude, the lake outflow would be on the order of 12,990 cfs and that for the 1 percent chance (100-year frequency) flood the lake outflow would be approximately 970 cfs.

Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Dam Safety" were not available, which is considered a deficiency.

b. Adequacy of Information. Due to the lack of engineering and construction data, the assessments reported herein were based on external conditions as determined during the visual inspection, recollections of the Owner, information from a Master Thesis in Civil Engineering at the University of Missouri at Rolla, and post-construction modifications by Russell and Axon Consulting Engineers, St. Louis, Missouri. The assessment of the hydrology of the watershed and capacity of the spillways were based on an hydrologic/hydraulic study as indicated in Section 5. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. The items concerning the safety of the dam noted in paragraph 7.1a and the remedial measures recommended in paragraph 7.2 should be accomplished in the near future.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. Since the dam is located within a Zone II seismic probability area, an earthquake of the magnitude predicted is not expected to produce a hazardous condition to the dam, provided that static stability conditions are satisfactory and conventional safety margins exist.

7.2 REMEDIAL MEASURES

a. Recommendations. The following actions are recommended:

(1) Based upon the criteria set forth in the recommended guidelines, the design of the dam should be revised to result in construction of structures to pass lake outflow resulting from a storm of probable maximum flood magnitude without endangering the stability of the dam.

(2) Obtain the necessary soil data and perform stability and seepage analyses in order to determine the structural stability of the dam for all operational conditions.

(3) Provide some form of slope protection at the intersection of the dam and the left abutment in order to prevent erosion by storm drainage runoff. Erosion of the embankment will reduce the section that could impair the stability of the dam.

(4) Provide some form of protection at the crest and downstream slope of the emergency spillway in order to prevent erosion by spillway flow. Erosion of the earth fill could result in failure of the dam.

(5) The possibility exists that flow emerging in the channel near the spillway weir could develop into a piping condition that would affect the operation of the lake. The Owner should investigate this condition and determine the corrective measures to be taken.

b. Operations and Maintenance (O & M) Procedures. The following O & M procedures are recommended:

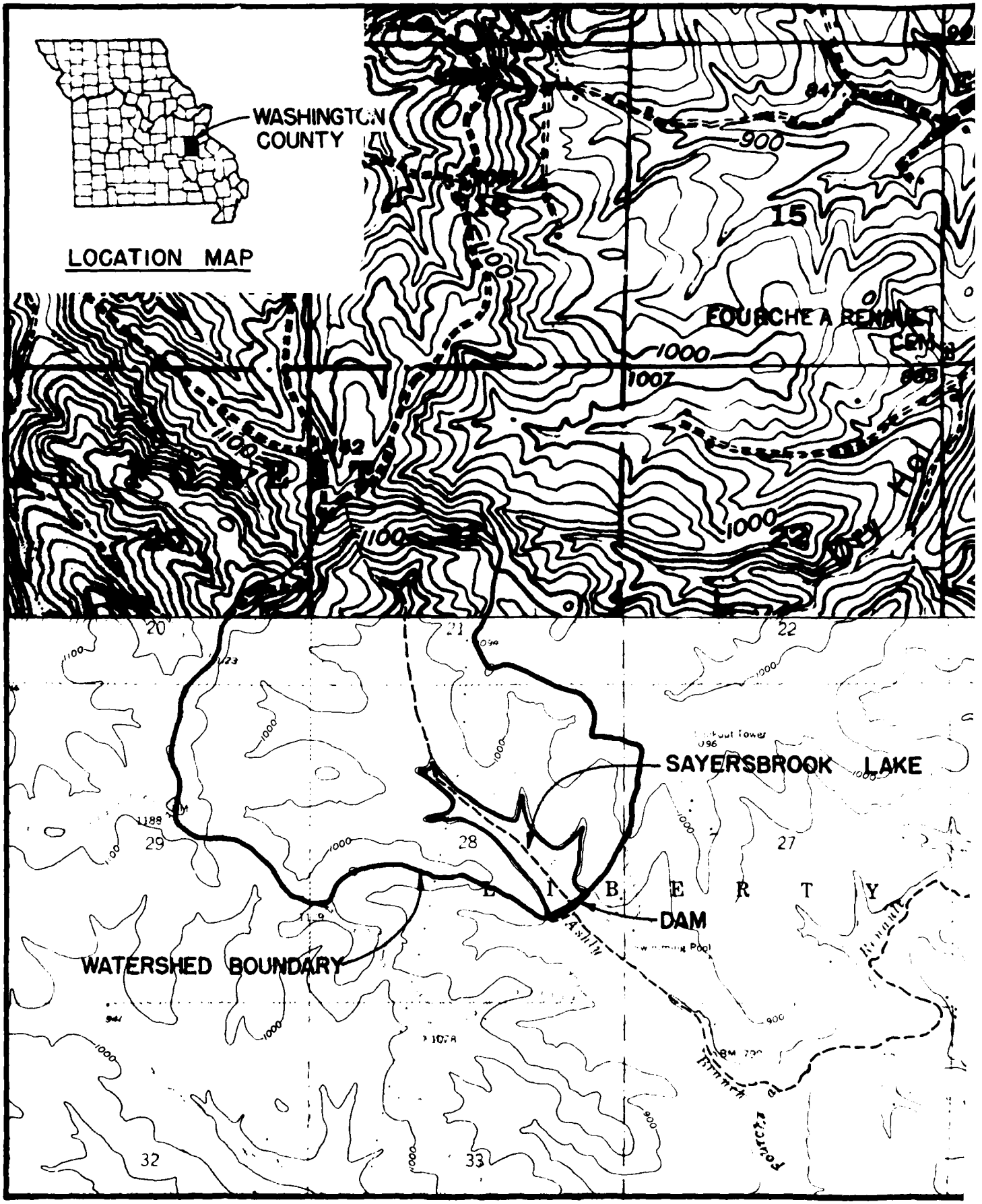
(1) Remove the trees and brush from the downstream face of the dam. The existing turf cover should be restored if destroyed or missing. Maintain the turf cover on the slope and below the dam at a height that will not hinder inspection or harbor burrowing animals. Voids created by burrowing animals and tree roots can provide pathways for seepage and the possibility of piping.

(2) Remove the 11-inch high planks from the spillway, except when required to raise the pool level for irrigation purposes. This would provide extra storage by lowering the normal pool.

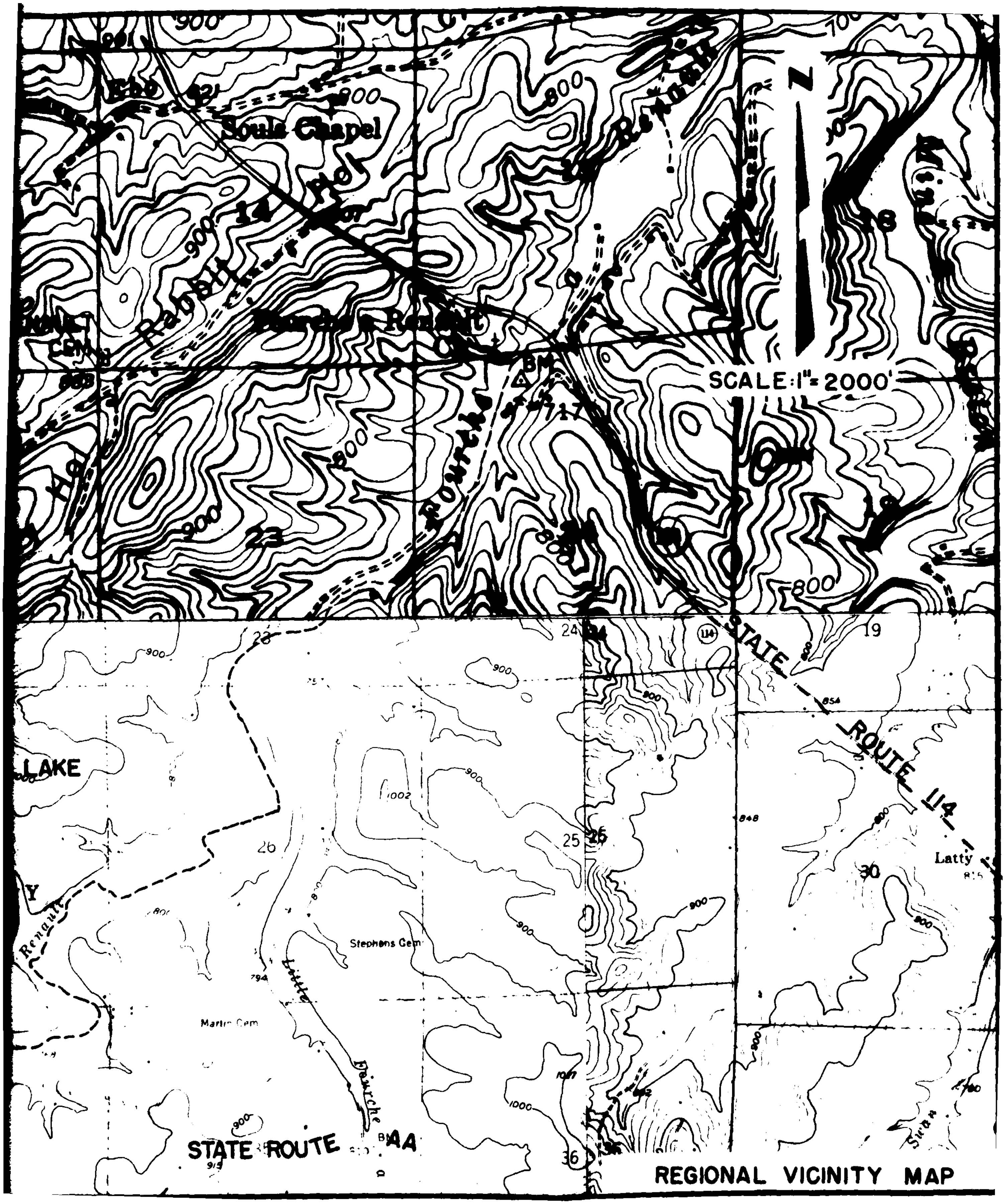
(3) The Owner should periodically inspect the lake and remove large pieces of floating debris that could clog the waterway at the principal spillway.

(4) Remove the trees and brush from the spillway exit channel section in order to allow flow to reach the downstream channel unrestricted. Restricting spillway discharge can result in flooding of the area adjacent to the dam and conditions detrimental to the stability of the embankment.

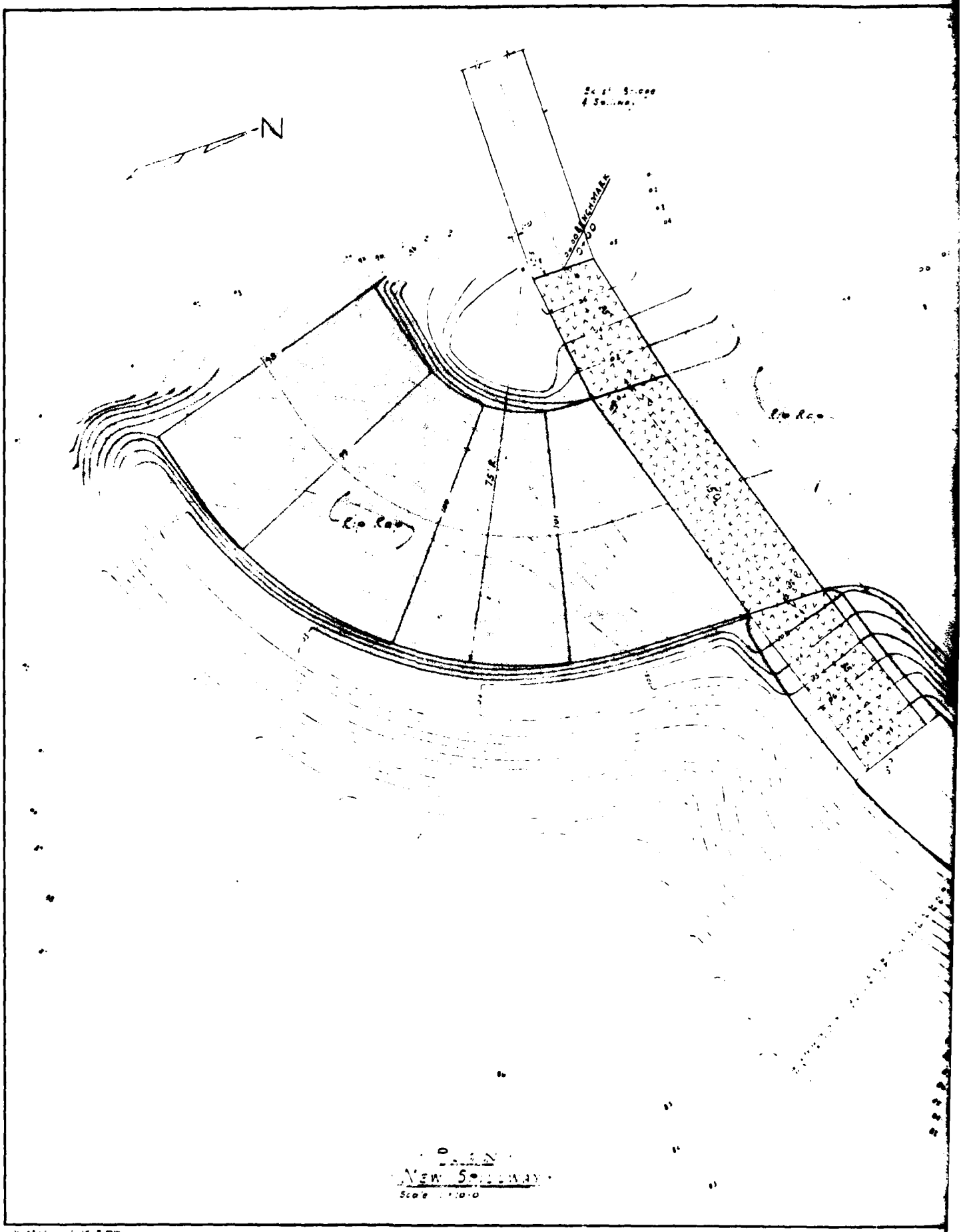
(5) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of earthfill type dams. It is also recommended, for future reference, that records be kept of all inspections and remedial measures.

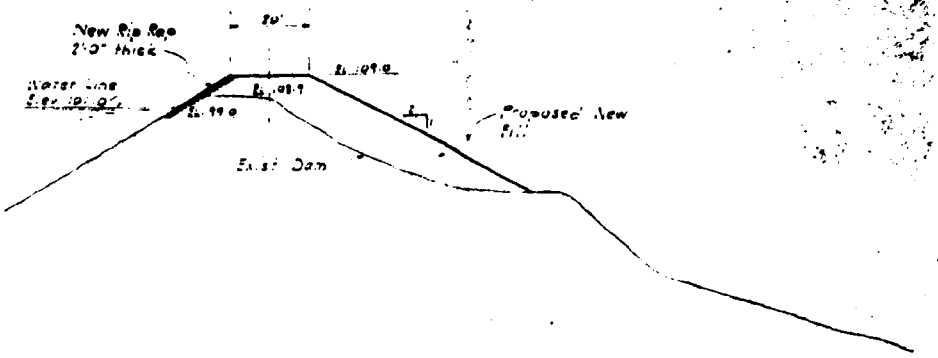

WASHINGTON COUNTY
LOCATION MAP
FOURCHE A RENAULT
SAYERSBROOK LAKE
DAM
WATERSHED BOUNDARY
15
20
21
22
27
28
29
32
33

APPE
TO



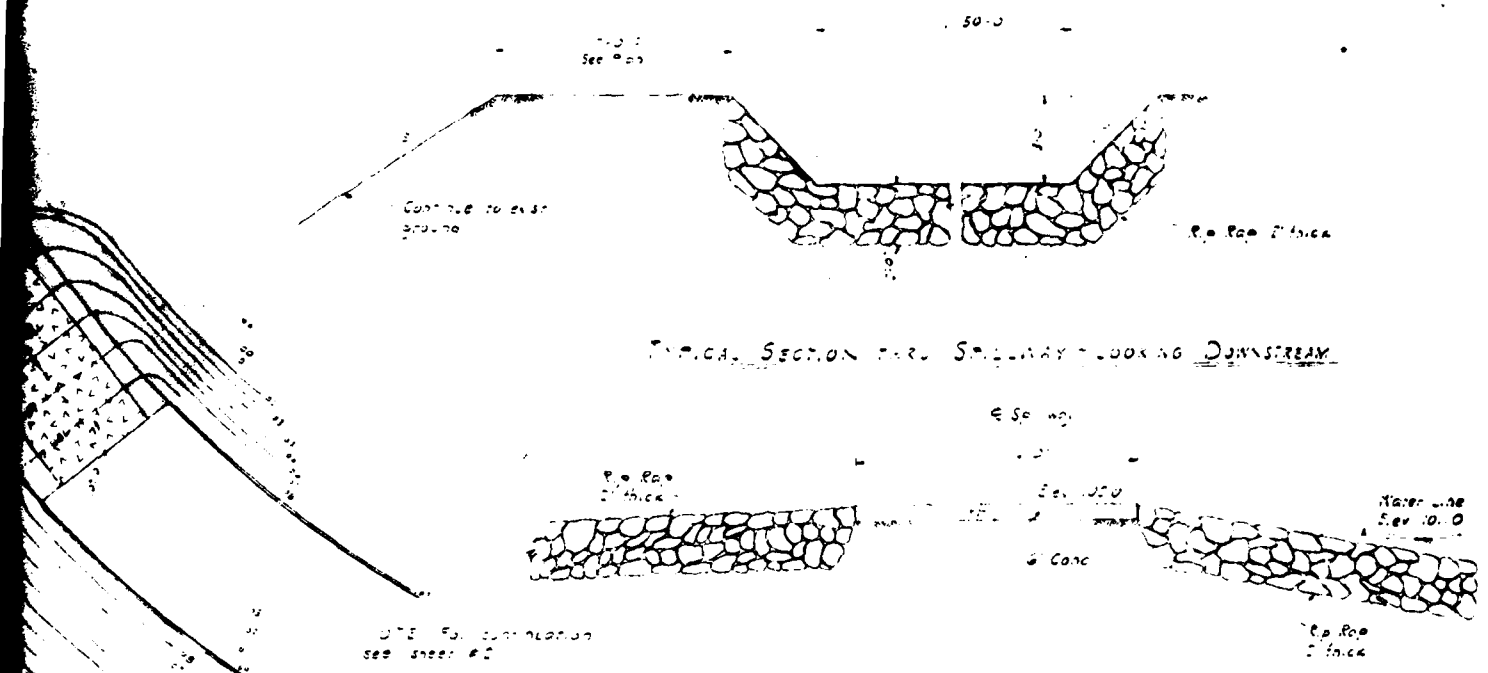
REGIONAL VICINITY MAP


N
New Sc...way
Scale 1:10·0



TYPICAL SECTION THRU DAM STA. 6+50

Scale: 1"=20'



TYPICAL SECTION THRU SPILLWAY LOOKING DOWNSTREAM

TYP. SECTION THRU SPILLWAY AT DAM

LEGEND

NEW RIP RAP PROTECTION

NEW CONC SPILLWAY

NO	DATE	DESCRIPTION	BY	CKD
		REVISIONS		

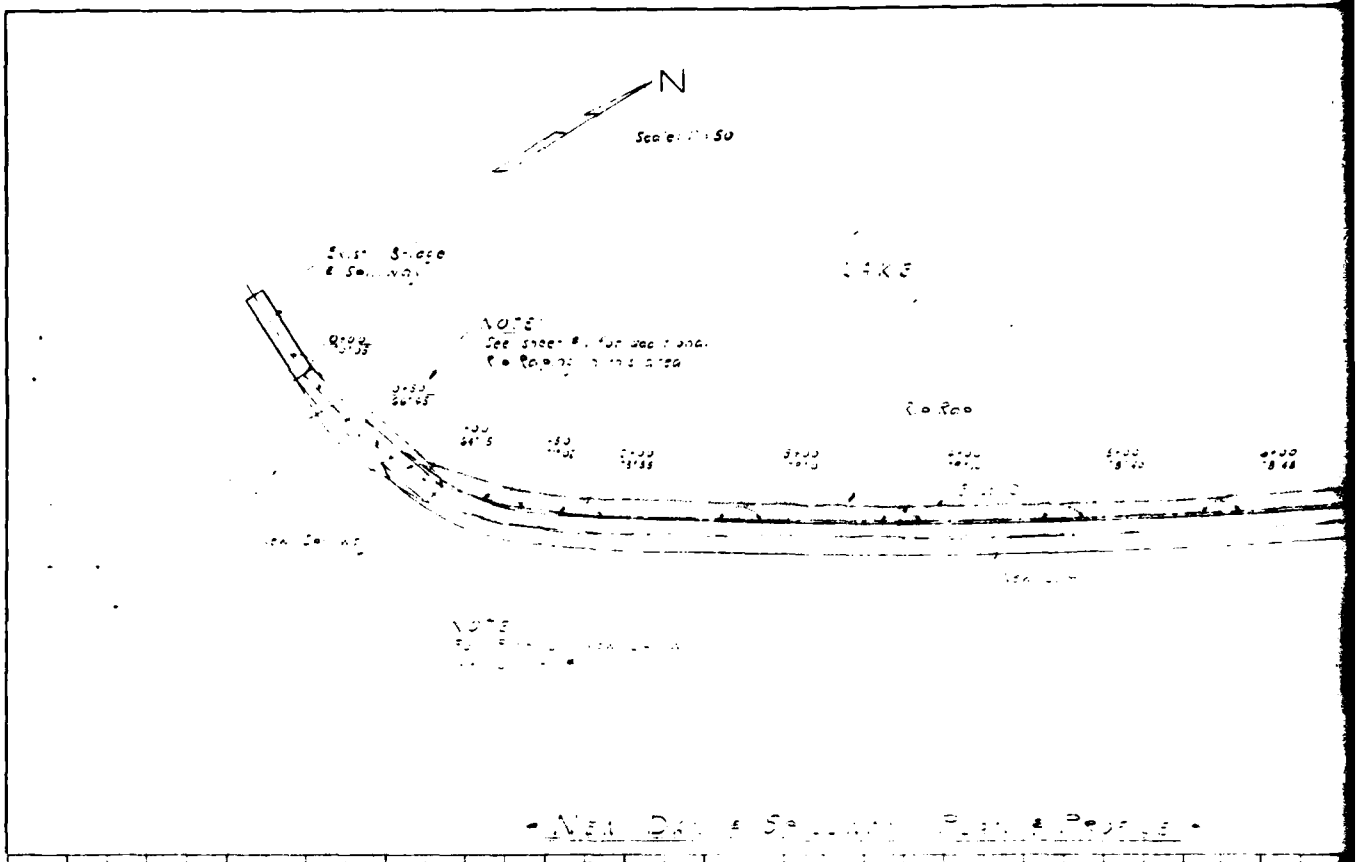
RUSSELL & AXON
Consulting Engineers, Incorporated
DAYTONA BEACH, FLA. ST. LOUIS, MO.

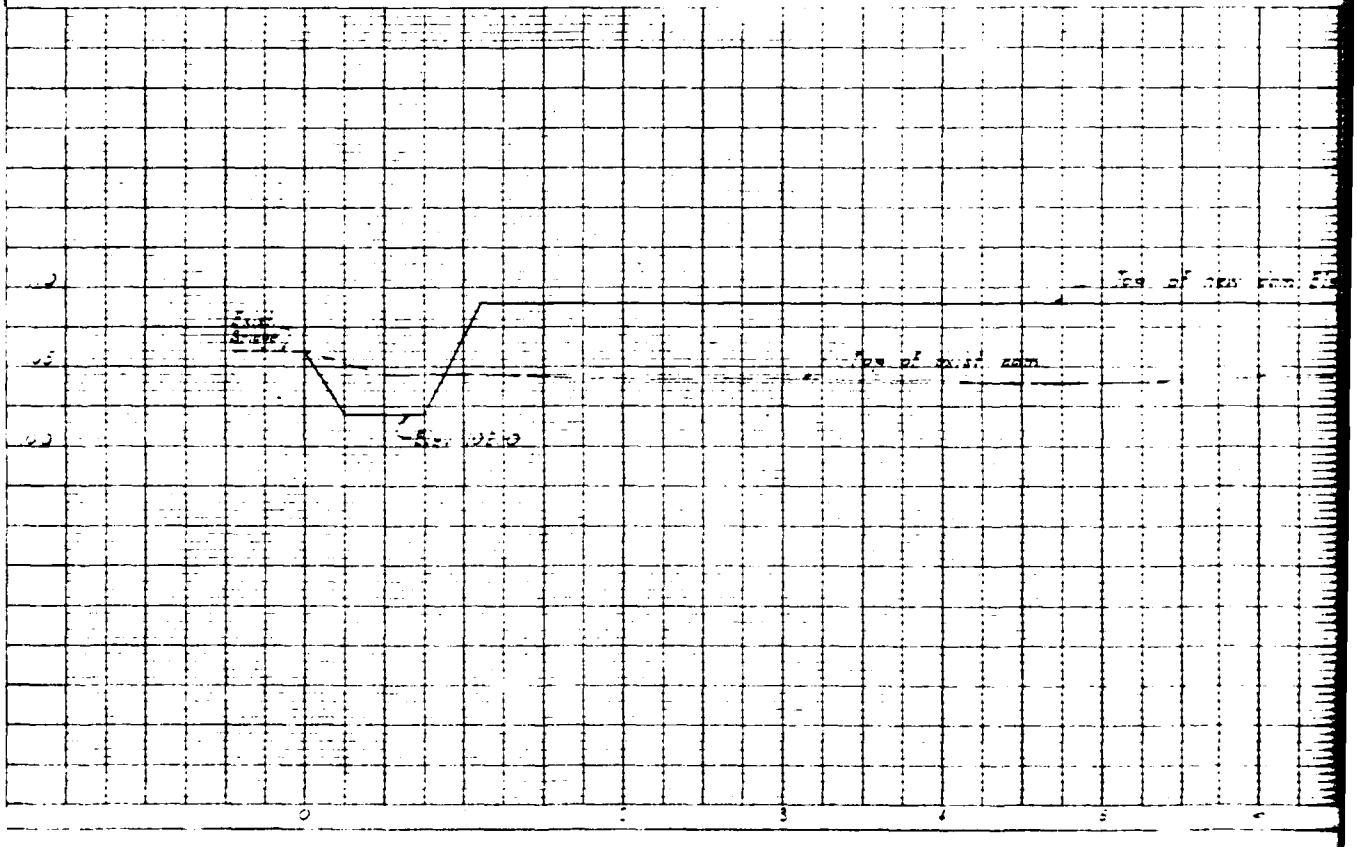
SAYERSBROOK
POTOSI, MO.
NEW SPILLWAY

DESIGNED BY	FILE NO.	SEAL
D E G	6932-13-1	
DRAWN BY	SHEET NO (1)	
R A L	OF 2 SHEETS	
CHECKED BY		
E W L		
DATE	SCALE AS NOTED	
11/69		

12

PLATE 2

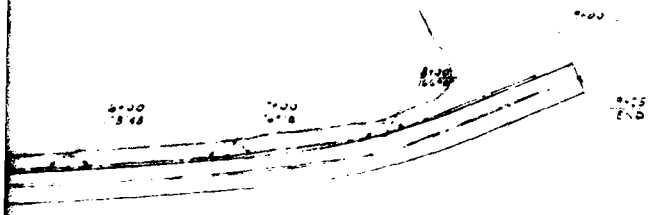

N
LAKE
NOTE



RUSSELL & AXON
Consulting Engineers, Incorporated
DAYTONA BEACH, FLA. ST. LOUIS, MO.

SAYERSBROOK
POTOSI, MO.
NEW SPILLWAY

DESIGNED BY	FILE NO.	SEAL
D.E.G.	6932-13-2	
DRAWN BY	SHEET NO. (2)	
R.A.L.	OF 2 SHEETS	
CHECKED BY		
DATE	SCALE As Noted	



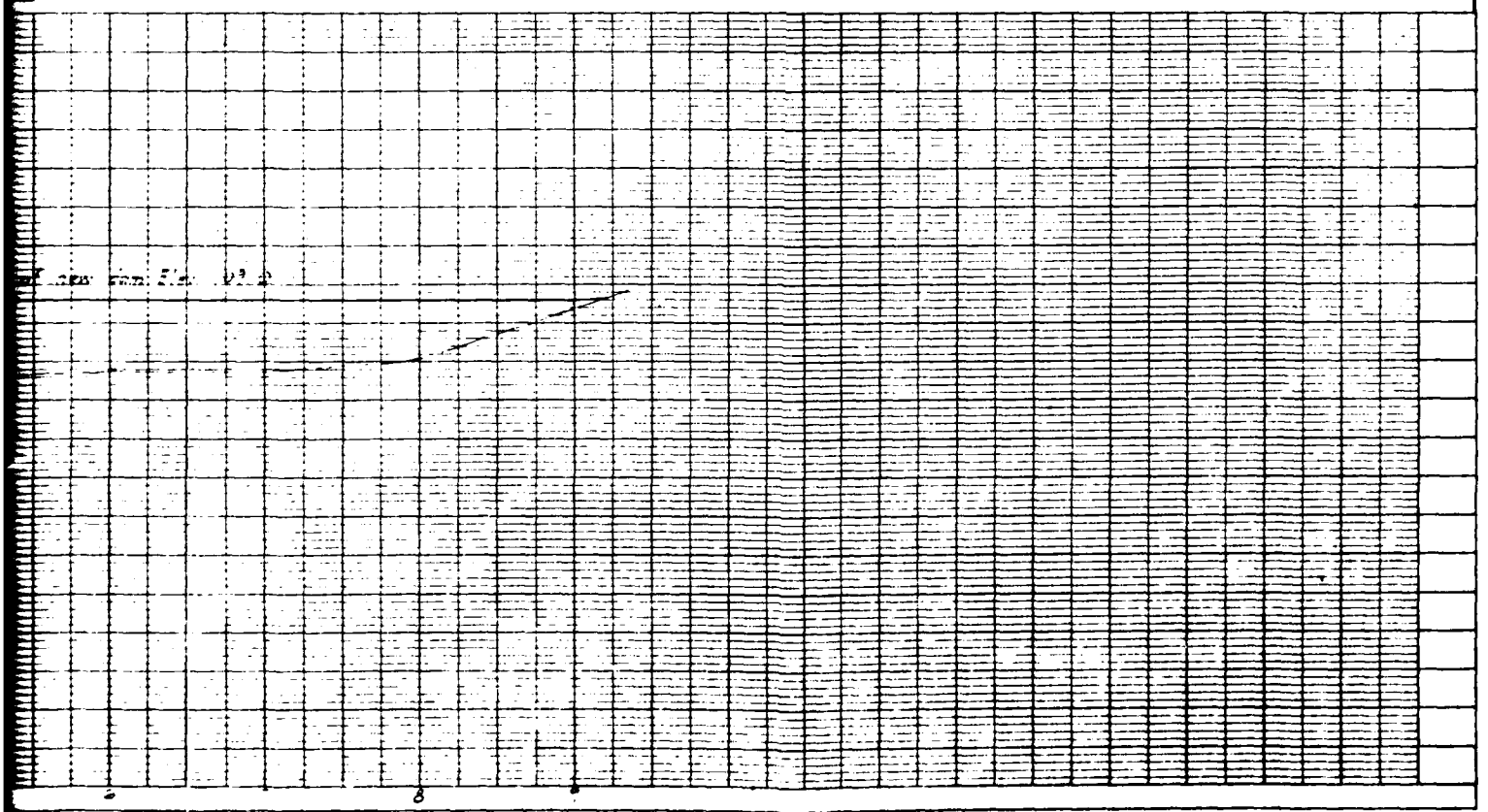
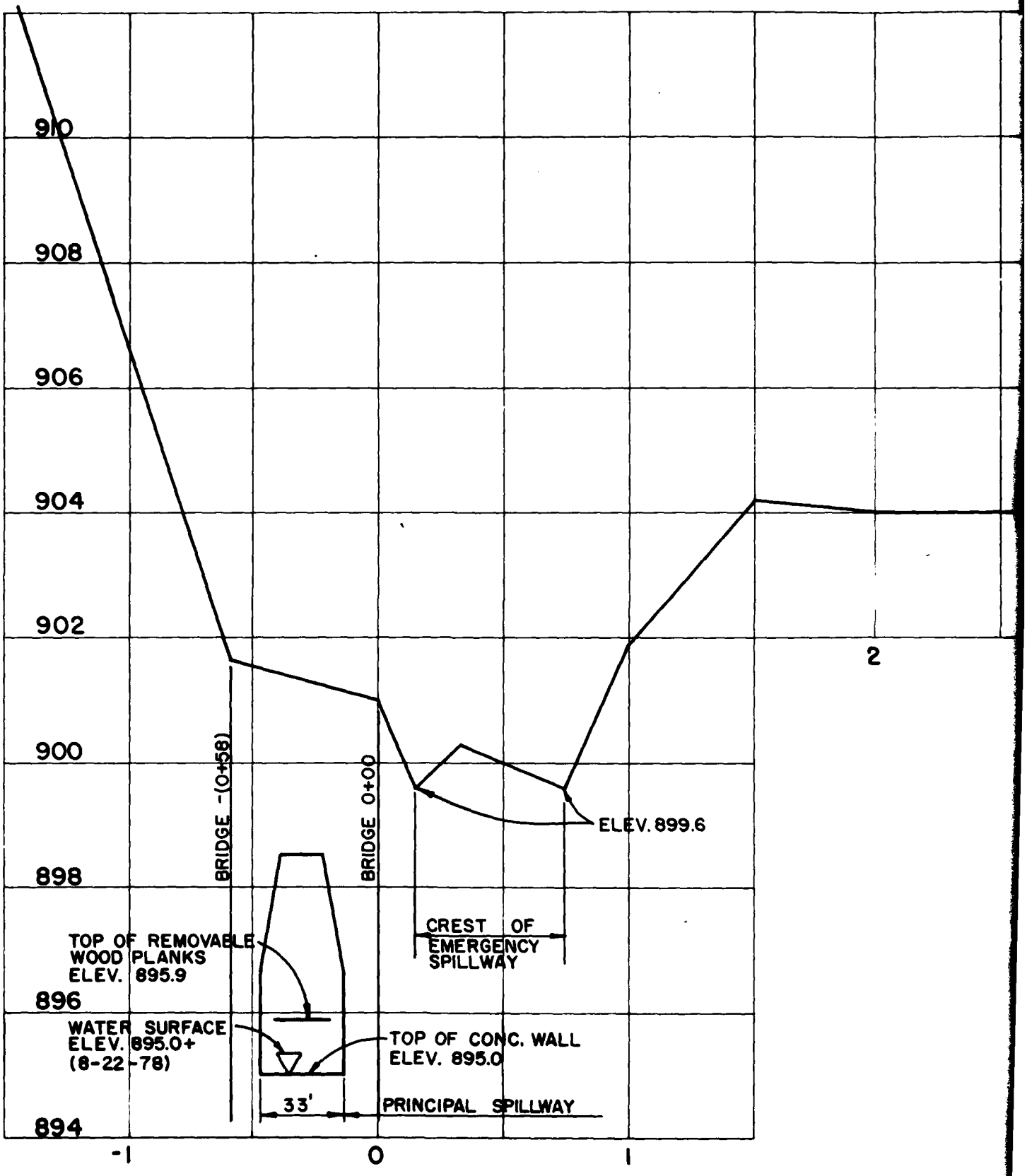
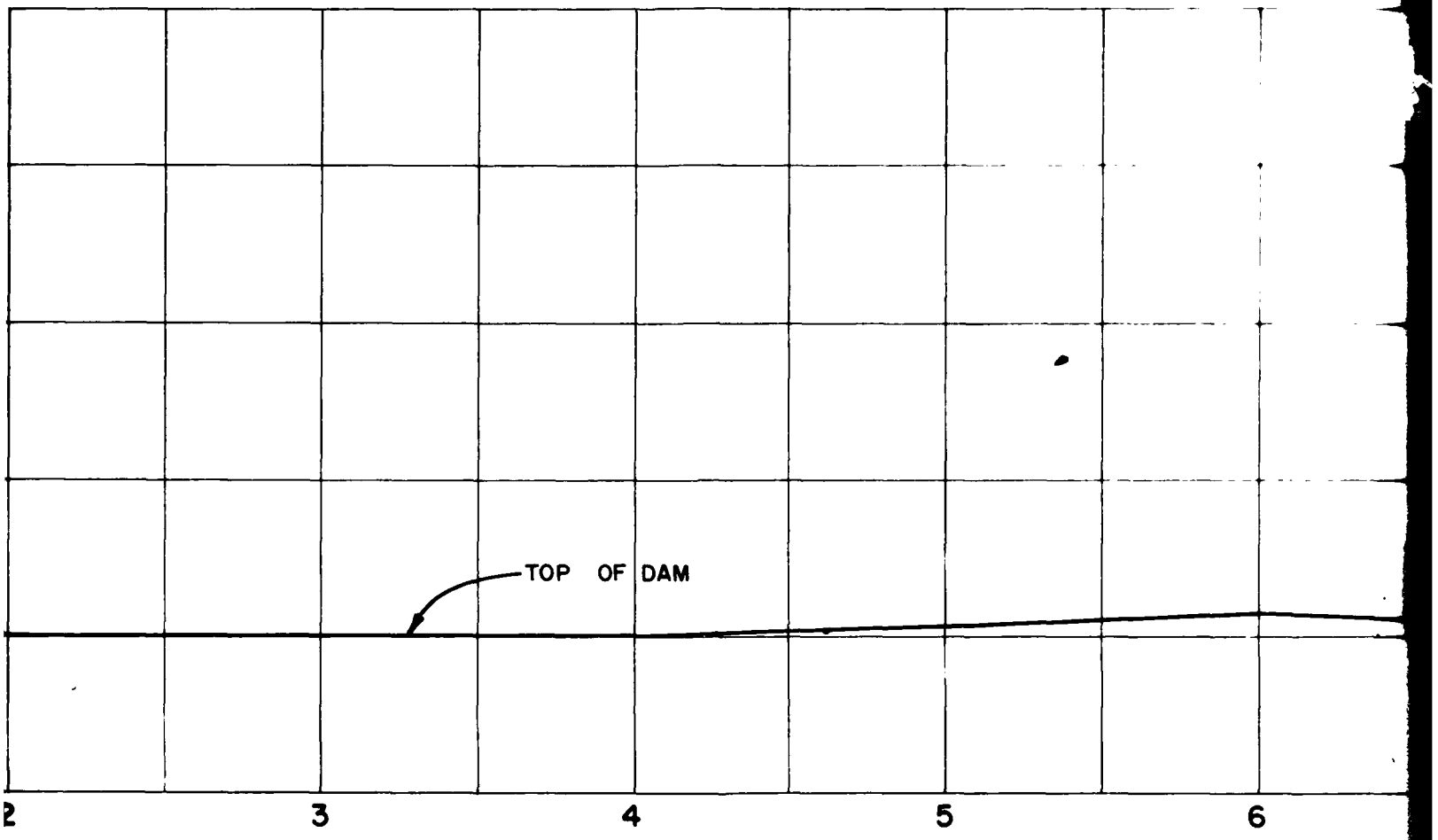


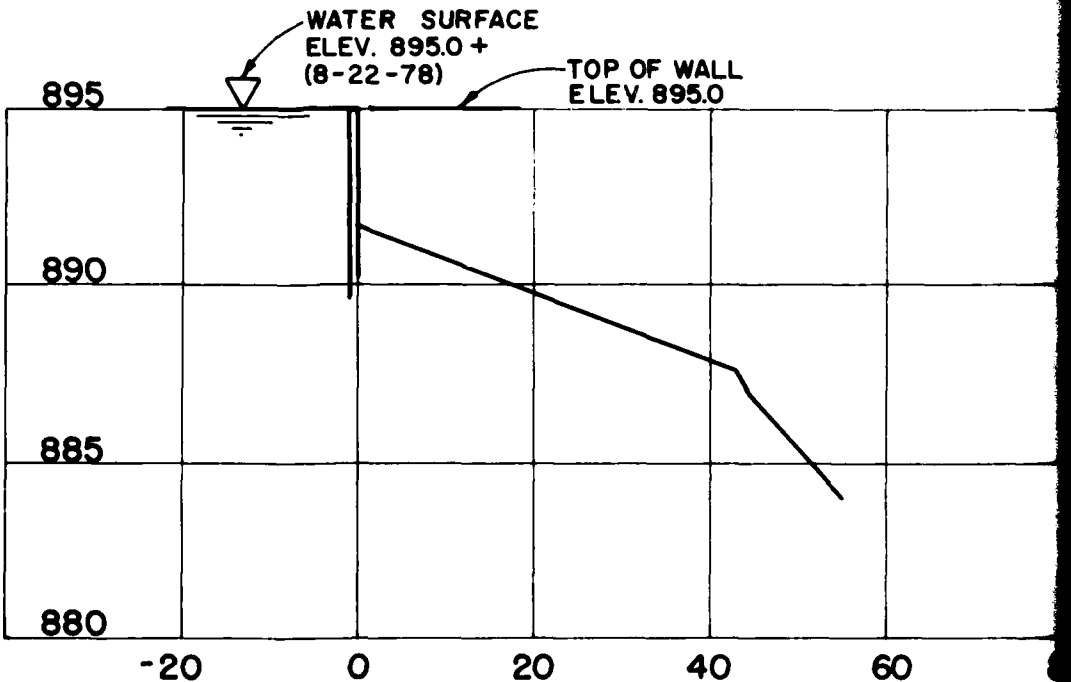
PLATE 3



PROFILE DAM CREST

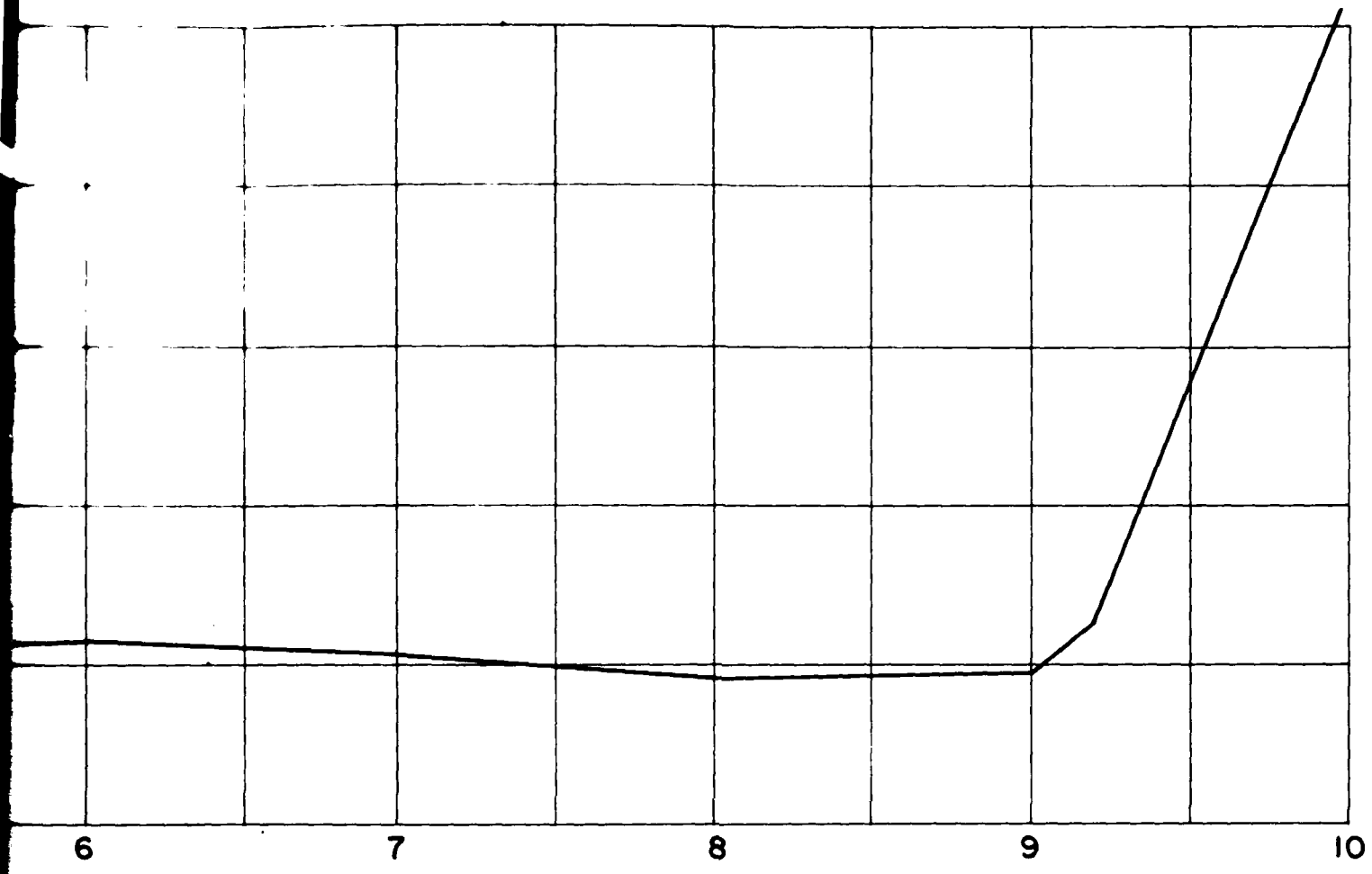
SCALES: 1"=2' V., 1"=50' H.

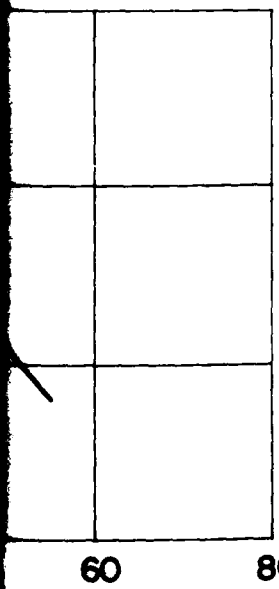




PROFILE PRINCIPAL SPILLWAY ℄

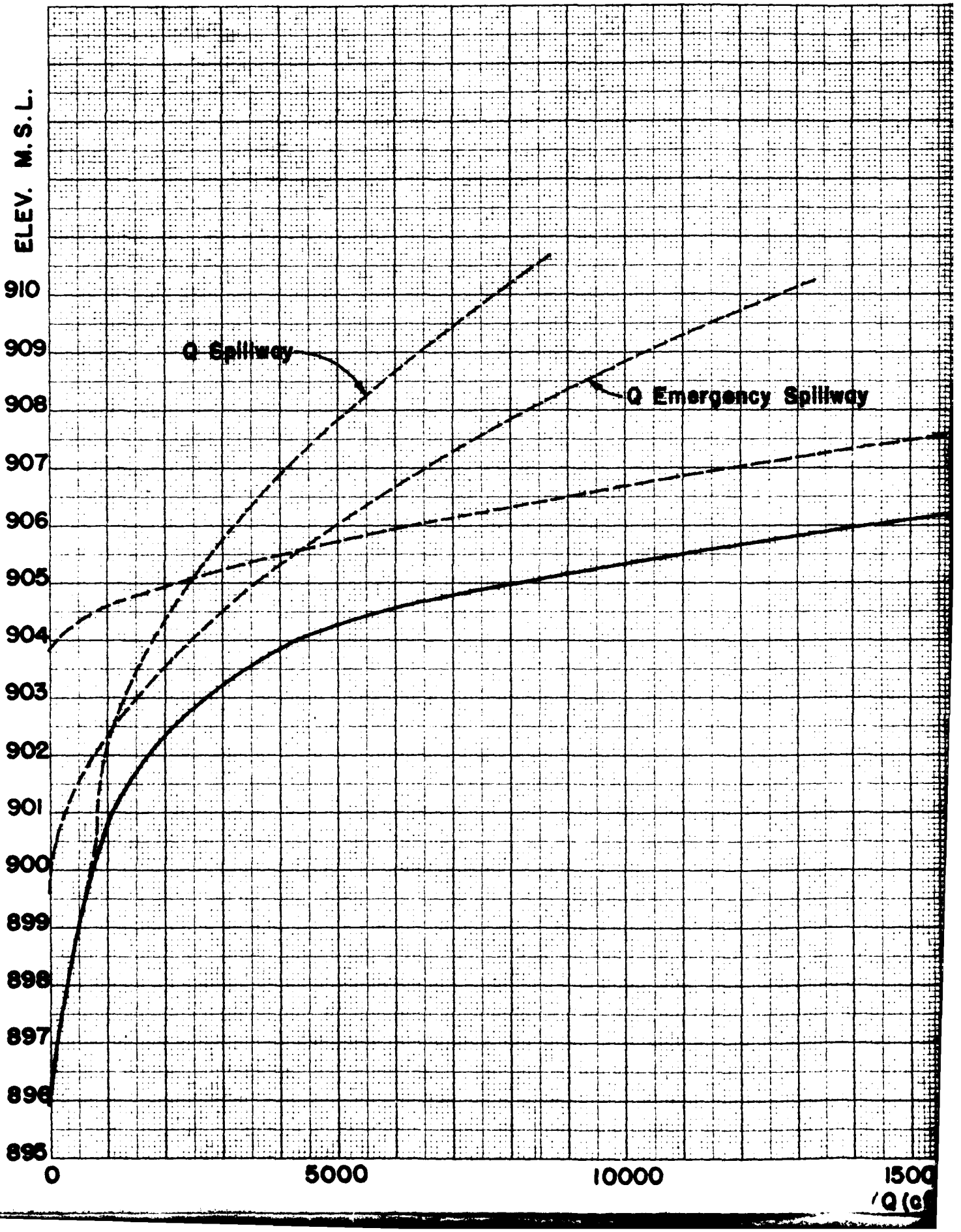
SCALES: 1" = 5' V., 1" = 20' H.

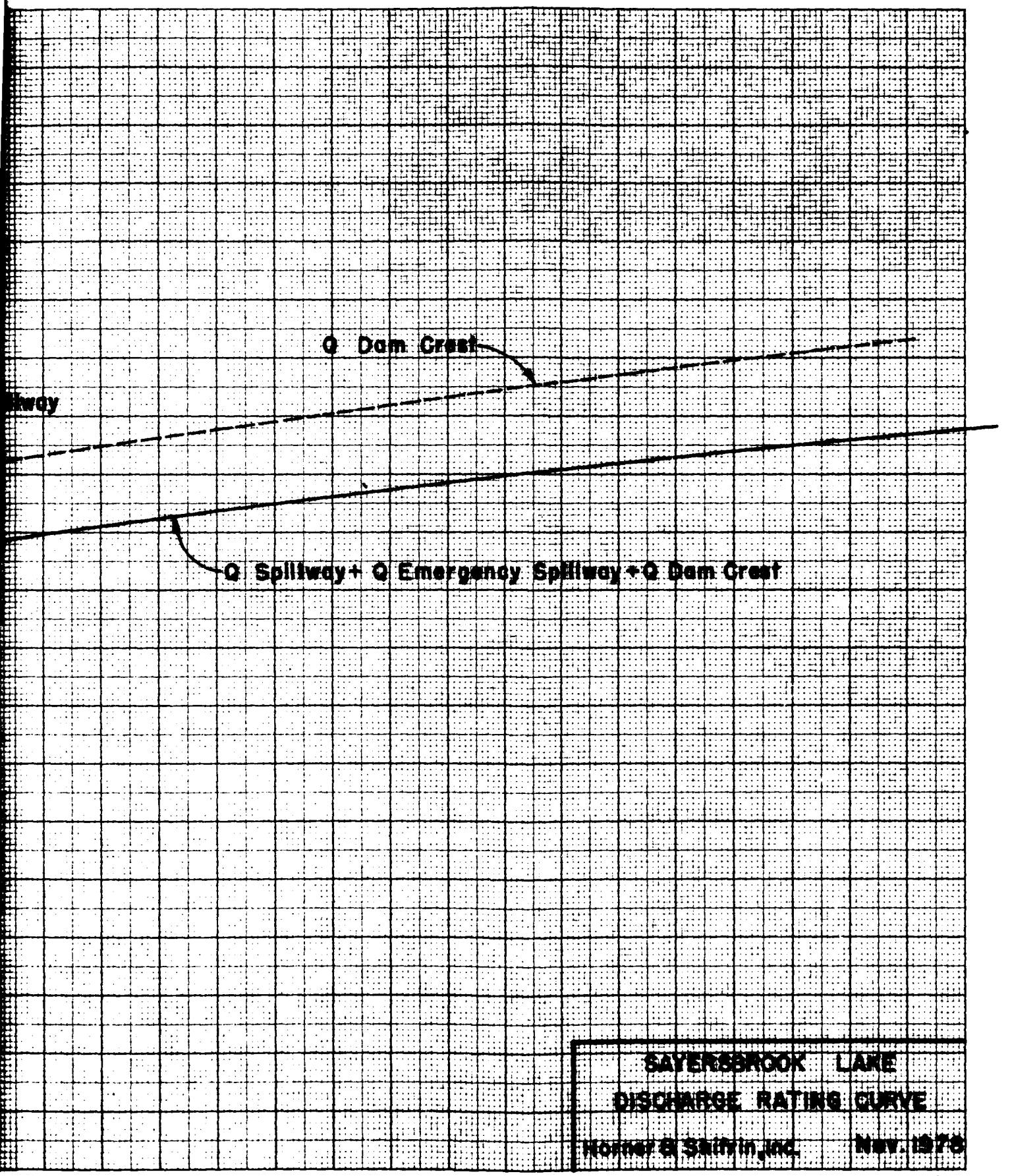




SAYERSBROOK LAKE
DAM & SPILLWAY PROFILES

Horner & Shifrin, Inc. Nov. 1978


ELEV. M.S.L.
910
909
908
907
906
905
904
903
902
901
900
899
898
897
896
895
0
5000
10000
1500
Q Spillway
Q Emergency Spillway
/Q (c



SAYERSBROOK LAKE

DISCHARGE RATING CURVE

Horner & Shifrin, Inc. Nov. 1978

PLATE 5

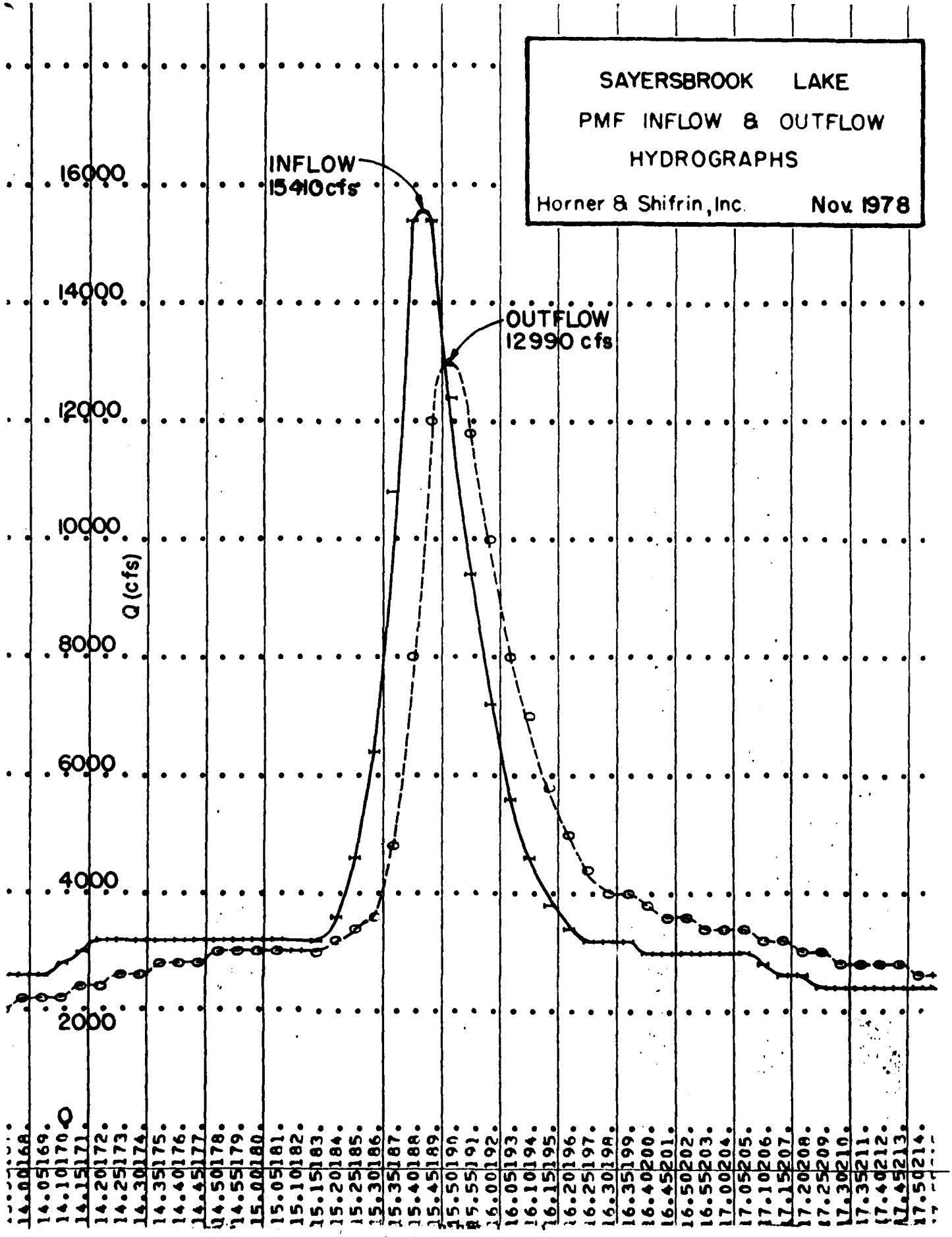

SAYERSBROOK LAKE
PMF INFLOW & OUTFLOW
HYDROGRAPHS
Horner & Shifrin, Inc. Nov. 1978
INFLOW
15410 cfs
OUTFLOW
12990 cfs
16000
14000
12000
10000
8000
6000
4000
2000
0
Q (cfs)
TIME (Hr./Min.) FROM BEGIN OF RAINFALL

PLATE 6

DAM: Sayers

LOCATION: Washington County

Sec. 28 T.38 N. R.1 E.

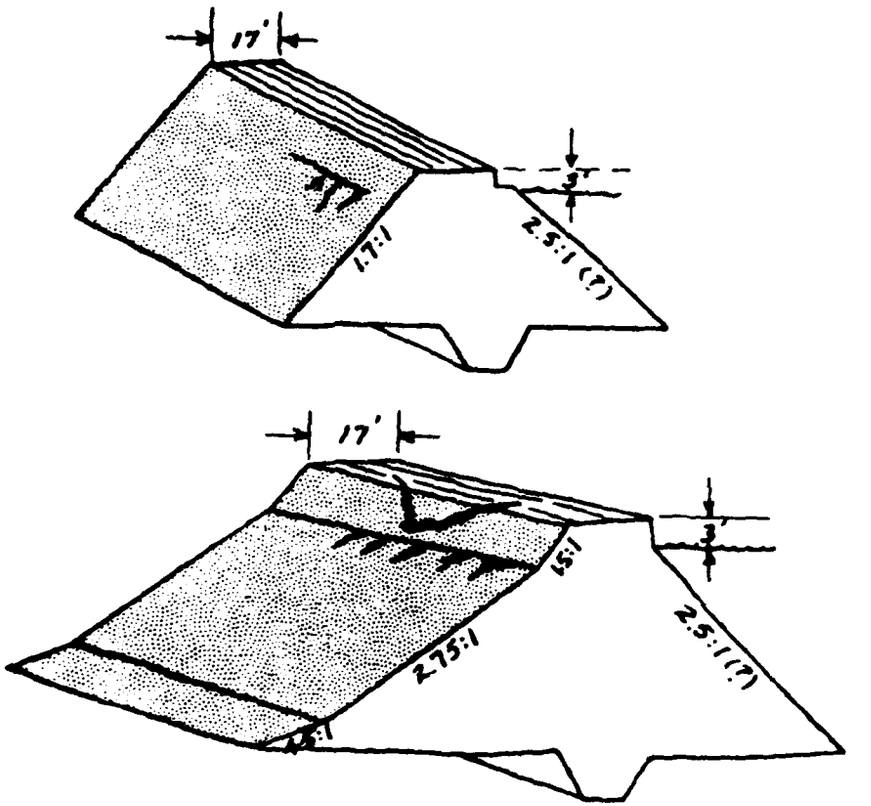
RESERVOIR SIZE: 43 Acres

EMBANKMENT: HEIGHT 60 ft.
LENGTH 900 ft.

BEDROCK FORMATION: Potosi

SOIL SERIES: Clarksville Stony Loam

TYPICAL DAM SECTION



SOIL CLASSIFICATION:

LL 105 PL 41 PI 64

GRADATION: % FINER

#10	100	#200	98
#40	99	10μ	96
#60	99	2μ	93
#100	98	1μ	90

COMPACTION CHARACTERISTICS
ASTM D 1557-66

MAX. DEN. 74 lb/cu ft OPT. MOIST. 42%

PREDOMINANT CLAY MINERALS:

Kaolinite

COMMENTS: CEC-44.9 pH-7.5 G_s-2.84

3 ft. freeboard

slides and seepage through steep crest section

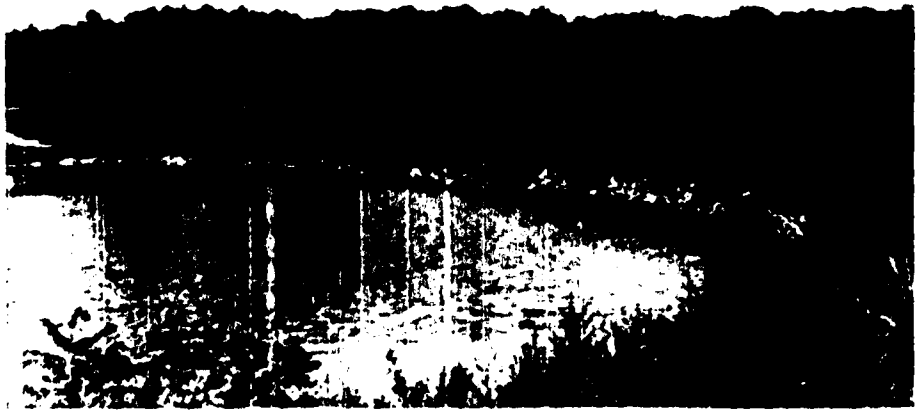
40 ft. wide spillway - eroded

cutoff trench (?)

Chart 2-1

APPENDIX

NO. 1: UPSTREAM FACE OF DAM AT RIGHT ABUTMENT



NO. 2: UPSTREAM FACE OF DAM AT LEFT ABUTMENT

NO. 3: DOWNSTREAM FACE OF DAM

NO. 4: OUTLET FOR LAKE DRAIN PIPES

NO. 5: SPILLWAY WEIR AND BRIDGE

NO. 6: SPILLWAY EXIT CHANNEL

HYDROLOGIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. mile, 24-hr. value equals 26.0 inches) from Hydrometeorological Report No. 33, one hundred year frequency (one square mile precipitation, 24-hr. value equals 7.22 inches) from the U.S. Weather Bureau Technical Paper No. 40.

b. Drainage area = 1.28 square miles
= 820 acres

c. SCS parameters
Lag time = 0.17 hours
Soil type CN = 91 (Soil type C, AMC III)

2. The principal spillway section consists of a broad-crested concrete U-shaped section. A concrete bridge structure crosses the spillway approach channel on the upstream side of the control section. For lake surface elevations lower than the underside of the bridge (elev. 898.5), spillway releases were determined as follows:

a. Spillway crest section properties (area, a and top width, t) were computed for various depths, d.

b. It was assumed that flow leaving the spillway crest would occur at critical depth. Flow at critical depth (Q_c) was computed as $Q_c = (\frac{a^3}{t}\, g)^{0.5}$ for the various depth, d.

Corresponding velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas.

c. Static lake levels corresponding to the various Q_c values passing over the spillway were computed as critical depths plus critical velocity head ($d_c + H_{vc}$), and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignificant friction losses across the length of the spillway.

For lake surface elevations higher than the underside of the bridge, the spillway opening was treated as an orifice, with discharges determined as follows:

$Q = Ca(2gH)^{0.5}$, where C = 0.6, a = area of opening, and H = head on orifice.

For lake surface elevations higher than the top of the bridge, in addition to orifice flow as described above, spillway releases over the top of the bridge were determined as flow over an irregular broad-crested section as described under 'a' thru 'c' above.

3. The emergency spillway consists of an approximately U-shaped broad-crested section for which conventional formulas do not apply. Spillway release rates were determined as described under '2a' thru '2c' above.

4. The profile of the dam crest is irregular, and flow over the dam crest cannot be determined by conventional weir forumlas. Flow quantities overtopping the dam crest were computed as described under '2a' thru '2c' above. Corresponding flows over the principal spillway, emergency spillway and dam crest for given elevations were added to obtain the combined outflow rating curve. This rating curve is shown on Plate 5. The inflow and outflow hydrographs for the PMF are shown on Plate 6.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  3 AUG 78
**********
    1                A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
    2                A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF SAYERSBROOK LAKE DAM
    3                A3       RATIOS OF PMF ROUTED THROUGH RESERVOIR
    4                B    288       0       5      -0      -0      -0      -0      -0      -0      -0
    5                B1     5
    6                J      1       3       1
    7                J1  0.49    0.50    1.00
    8                K      0  INFLOW                                      3       1
    9                K1       INFLOW HYDROGRAPH
   10                M      1       2    1.28                                  1.0                     1
   11                P      0    26.0     102     120     130
   12                T                                                                  -1     -91
   13                W2          0.17
   14                X   -1.0    -.10     2.0
   15                K      1     DAM                             2       3       1
   16                K1       RESERVOIR ROUTING BY MODIFIED PULS
   17                Y                                       1       1
   18                Y1     1                                                   708      -1
   19                Y4 895.9     897   898.5   900.5     901     902     903     904     905     906
   20                Y4   907     908     910
   21                Y5     0     110     390     890    1050    1620    2750    4200    8180   14380
   22                Y5 22410   32120   55160
   23                SA     0      38      48      91
   24                SE   840   895.9     900     920
   25                SS 895.9
   26                SD 903.8
   27                K     99
```

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**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  3 AUG 78
**********
    1          A1       ANALYSIS OF DAM OVERTOPPING USING 100 YR FLOOD
    2          A2       HYDROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF SAYERSBROOK LAKE DAM
    3          A3       100 YR FLOOD ROUTED THROUGH RESERVOIR
    4          R    288        0        5       -0       -0       -0       -0       -0       -0       -0
    5          B1     5
    6          J      1        1        1
    7          J1   1.0
    8          K      0  INFLOW                                    3        1
    9          K1       INFLOW HYDROGRAPH
   10          M      0        2     1.28                    1.0                         1
   11          O    288
   12          O1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
   13          O1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
   14          O1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
   15          O1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
   16          O1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
   17          O1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
   18          O1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
   19          O1  .007     .007     .014     .014     .014     .014     .014     .014     .014     .014
   20          O1  .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
   21          O1  .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
   22          O1  .014     .014     .014     .014     .014     .014     .014     .014     .022     .022
   23          O1  .022     .022     .022     .022     .022     .022     .022     .022     .022     .022
   24          O1  .022     .022     .022     .022     .022     .022     .031     .031     .031     .031
   25          O1  .031     .031     .061     .061     .061     .061     .061     .061     .132     .132
   26          O1  .133     .251     .251     .550     .823     .382     .251     .133     .132     .132
   27          O1  .061     .061     .061     .061     .061     .061     .031     .031     .031     .031
   28          O1  .031     .031     .022     .022     .022     .022     .022     .022     .022     .022
   29          O1  .022     .022     .022     .022     .022     .022     .022     .022     .022     .022
   30          O1  .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
   31          O1  .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
   32          O1  .014     .014     .014     .014     .014     .014     .014     .014     .014     .014
   33          O1  .014     .014     .014     .014     .014     .014     .007     .007     .007     .007
   34          O1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
   35          O1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
   36          O1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
   37          O1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
   38          O1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
   39          O1  .007     .007     .007     .007     .007     .007     .007     .007     .007     .007
   40          O1  .007     .007     .007     .007     .007     .007     .007     .007
```

```
40          O1   .007     .007     .007     .007     .007     .007     .007     .007
41          T                                                            -1      -91
42          W2             0.17
43          X    -1.0      -.10      2.0
44          K       1       DAM                          2        3        1
45          K1          RESERVOIR ROUTING BY MODIFIED PULS
46          Y                                        1        1
47          Y1      1                                                    708      -1
48          Y4  895.9      897    898.5    900.5      901      902      903      904      905      906
49          Y4    907      908      910
50          Y5      0      110      390      890     1050     1620     2750     4200     8180    14380
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51          Y5  22410    32120    55160
52          $A      0       38       48       91
53          $E    840    895.9      900      920
54          $S  895.9
55          $D  903.8
56          K      99
```

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	895.89	895.90	903.80
	STORAGE	708.	708.	1080.
	OUTFLOW	0.	0.	3910.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.49	903.81	.01	1080.	3920.	.08	16.00	0.00
.50	903.89	.09	1085.	4036.	.17	16.00	0.00
1.00	905.78	1.98	1193.	12993.	1.08	15.83	0.00